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Relation of Temperature and Moisture to Brood Development
of the Western Pine Beetle

by

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Portland, Oregon
May 1931

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The western pine beetle developed very poor broods under the entire range of temperature and moisture conditions obtained on blocks in the laboratory and block in the field. Brood development of this insect began very close to 50 degrees F. and increased directly with the temperature up to about 65 degrees. The temperature at which the greatest percentage of insects were able to complete normal development was about 75 degrees F. while the temperature at which development took place with the greatest velocity was 50 to 55 degrees above this. Temperatures below 50 degrees resulted in no development over a period of nearly 50 days. We have therefore referred to 50 degrees F. as the threshold of development. Constant temperatures of 75 degrees and above usually proved fatal to all stages of this insect.

Constant temperatures of 50 degrees F. gave the maximum rate of brood development with a single exception where brood matured more rapidly at 55 degrees. Brood development at a constant temperature of 75 degrees progressed more slowly than at 55 degrees but survival was usually better at the lower temperature. At constant temperatures of 55 degrees the rate of development increased materially. Some development was apparent at constant temperatures of 50 and 55 degrees F. but constant temperatures of 65, 70 and 75 degrees resulted in apparent brood development while the brood remained alive in all stages and the adults were feebly active becoming normally active when moved to room temperatures.

The pheromone content of the infested blocks either remained nearly constant or increased throughout brood development in all cases except at temperatures of 100 degrees or higher. It was abnormally high at all times averaging from 510 to 530 per cent in all but the blocks at higher temperatures.

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Relation of Temperature and Moisture to Brood Development of the Western Pine Beetle

Abstract

A laboratory study on brood development of the western pine beetle was conducted during the past winter in the Bureau of Entomology Laboratory at Berkeley, California. It is supplementary to similar brood studies made in the field on this insect during the past two years.

Western yellow pine blocks were brought in from the field and caged with infested bark for attack. The blocks were then distributed in constant temperature compartments ranging from 35 to 105 degrees F. In these chambers brood development was observed and records on temperature and phloem moisture were obtained. Over 5000 larvae were obtained for the study by shaving up infested bark. They were sorted and grouped in lots of known numbers (50, 75 and 100) and subjected to constant temperatures for further observations on development. Tests were also made on a large number of larvae alternating the groups for a different number of hours daily between a low limiting temperature and a high optimum temperature. Subsequent development was observed and recorded. Eggs were isolated and incubated at a range of low temperatures to determine the lowest point at which they could hatch.

The western pine beetle developed very poor broods under the entire range of temperature and moisture conditions obtained on blocks in the laboratory and slash in the field. Brood development of this insect began very close to 50 degrees F. and increased directly with the temperature up to about 85 degrees. The temperature at which the greatest percentage of insects were able to complete normal development was about 75 degrees F. while the temperature at which development took place with the greatest velocity was 10 to 15 degrees above this. Temperatures below 50 degrees resulted in no development over a period of nearly 50 days. We have therefore referred to 50 degrees F. as the threshold of development. Constant temperatures of 95 degrees and above usually proved fatal to all stages of this insect.

Constant temperatures of 85 degrees F. gave the maximum rate of brood development with a single exception where brood matured more rapidly at 95 degrees. Brood development at a constant temperature of 75 degrees progressed more slowly than at 85 degrees but survival was usually better at the lower temperature. At constant temperatures of 65 degrees the rate of development decreased materially. Some development was apparent at constant temperatures of 55 and 52 degrees F. but constant temperatures of 48, 40 and 36 degrees permitted no apparent brood development altho the brood remained alive in all stages and the adults were feebly active becoming normally active when warmed to room temperatures.

The phloem moisture of the infested blocks either remained nearly constant or increased throughout brood development in all cases except at temperatures of 100 degrees or higher. It was abnormally high at all times averaging from 200 to 300 per cent in all but the blocks at higher temperatures.

Abstract

A laboratory study on brood development of the western pine beetle was conducted during the past winter in the Bureau of Entomology and Plant Quarantine, California. It is supplementary to similar brood studies made in the field on this insect during the past two years.

Western yellow pine blocks were brought in from the field and aged with infested bark for attack. The blocks were then distributed in constant temperature environments ranging from 35 to 100 degrees F. In these chambers brood development was observed and records on temperature and moisture were obtained. Over 2500 larvae were obtained for the study by moving up infested bark. They were sorted and placed in jars of known capacity (50, 75 and 100) and subjected to constant temperature for further observation on development. Tests were also made on a large number of larvae eliminating the groups for a different number of hours daily between a low limiting temperature and a high optimum temperature. Subsequent development was observed and recorded. Eggs were isolated and incubated at a range of low temperatures to determine the lowest point at which they could hatch.

The western pine beetle developed very poor broods under the entire range of temperatures and moisture conditions obtained in blocks in the laboratory and also in the field. Brood development of this insect began very close to 55 degrees F. and increased directly with the temperature up to about 85 degrees. The temperature at which the greatest percentage of insects were able to complete normal development was about 75 degrees F. while the temperature at which development took place with the greatest velocity was 50 to 75 degrees above this. Temperatures below 50 degrees resulted in no development over a period of nearly 60 days. We have therefore referred to 50 degrees F. as the threshold of development. Constant temperatures of 55 degrees and above usually proved fatal to all stages of this insect.

Constant temperatures of 55 degrees F. gave the maximum rate of brood development with a slight exception where brood matured more rapidly at 75 degrees. Brood development at a constant temperature of 75 degrees progressed more slowly than at 55 degrees but survival was usually better at the lower temperature. At constant temperatures of 55 degrees the rate of development decreased materially. Some development was apparent at constant temperatures of 35 and 50 degrees F. but constant low-temperature of 45, 40 and 35 degrees permitted no apparent brood development at all. The brood remained alive in all stages and the adults were totally active becoming normally active when warmed to room temperature.

The moisture relation of the infested blocks either remained nearly constant or increased throughout brood development in all cases except at temperatures of 100 degrees or higher. It was generally high at all times averaging from 200 to 300 per cent in all but one block at higher temperatures.

Tests with about 3000 mature larvae indicated that the rate of development of the more nearly mature brood depended directly upon the hour-degrees of effective temperature above the threshold of development. In other words, a definite number of cumulative day or hour-degrees of temperature was necessary for the completion of a specific stage in the life history. As determined by the development from pupae to adults it was found to be slightly over four thousand hour-degrees.

Brood mortality in blocks under controlled temperature conditions was heaviest in the young larval stages. A green fungus^{*} was almost invariably associated with the decaying bodies of the dead larvae. What appeared to be dwarfed or stunted larvae tunneled about in the inner bark of some blocks over periods of six and seven weeks and formed abnormally long winding larval galleries. Eggs hatched at approximately the same temperatures at which larval and pupal development began.

Introduction

Studies on brood development of the western pine beetle (*Dendroctonus brevicomis* Lec.) have been conducted during the past two summers within a range of temperature and moisture conditions limited to those which could be obtained in the field. During the past winter these studies were continued in the laboratory at Berkeley, California, where more accurate control of the conditions affecting insect development was possible.

Largely through the suggestions and assistance of Mr. J. M. Miller and other members of the Berkeley Station a creditable showing was made on the study during the time spent on it. Mr. R. N. Jeffrey continued the studies on a second series of infested blocks during April and part of May after the writer had returned to the Portland office.

Temperature and its effect upon the development of plant and animal life has probably been more thoroughly studied than any other single factor. Miller^{*} has contributed an outstanding paper on fatal high and low temperatures for the western pine beetle. Little information has been published relative to the temperatures necessary for brood development of this insect. However the importance of temperature as applied to field conditions has been fully appreciated as evidenced by the following general note taken from the brood records at Ashland, Oregon. "Overwintered broods in the south side of a tree may emerge from 27-41 days earlier than on the north side of the same tree and average 33 days earlier. Broods in trees of the first seasonal generation which emerge during the summer months and do not overwinter, appear to develop at about the same rate on all sides of the tree". In this phase of the study we were able to determine a few points heretofore unknown regarding the effect of temperature upon development and activity of brood stages of the western pine beetle.

^{*}Miller, J.M., High and low lethal temperatures for broods of the western pine beetle.

Moisture, or in the case of most insects atmospheric humidity, has in the past received much less attention than temperature. Because of the little possible effect of atmospheric humidity on broods of the western pine beetle the term moisture will be used in this report as referring to moisture of the phloem. Since this media and food supply is usually in a more or less saturated condition and completely surrounds the insects the moisture content of this layer of inner bark should reflect the moisture conditions to which the insects are subjected. Unfortunately control of phloem moisture even in blocks of wood in the laboratory has not been possible, and we have therefore been forced to record the moisture as we have found it.

The object of the study was to determine the effect of temperature and moisture in limiting the development of western pine beetle broods and the optimum conditions for brood development. Such knowledge is important in helping us to recognize the general climatic conditions which favor or retard western pine beetle epidemics from one year to another and the conditions in slash which are favorable or unfavorable for brood development.

This report supplements the studies on brood development previously reported by the writer in station reports of 1930 and 1931, and it is hoped that the information presented herein may add something further to our knowledge of the activities of the western pine beetle.

Materials and Methods

The equipment used in the laboratory study was essentially the same as that used in the field except for the addition of constant temperature controlled compartments.

Temperature equipment.

Through the courtesy of the University of California and the efforts of Mr. Miller, constant temperature cabinets were either borrowed or built for the purpose of housing infested pine blocks during the brood development study. In this way a series of temperatures ranging from 35 to 106 degrees Fahrenheit were obtained. The low temperature frigidaire machine was also used in part of the work. Space in chambers kept at constant temperatures of 36, 40, 45, and 52 degrees F. were loaned to us by the University. Two other cabinets with high temperatures of 85 and 104 degrees were also loaned for the first tests but were not used during the second. Space with temperatures around 60, 65 and 70 degrees was obtained by manipulation of storage and office space in Giannini Hall. Temperature constants of 75, 85, 95 and 100 degrees were made possible through the construction, by Mr. Wagner, of a four chambered cabinet wired for electric heating bulbs and ventilated by the use of two small sliding doors in the main door of each chamber. This cabinet was kept in the cork lined constant temperature room so that better regulation of it would be insured. A small electric fan was used in the large chamber to increase ventilation and to insure the same amount at all times. After the compartments of the cabinet were once regulated, they operated within a range of plus or minus 2 degrees and usually less.

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Standard Fahrenheit thermometers were used to check the temperatures of all compartments used and to follow temperature lag in the jars when transferred from one temperature to another. All temperature determinations were made on the Fahrenheit basis. The thermometers were graduated from -1° to 22° degrees.

Thermographs were set up in all but the smaller thermostated compartments so that complete temperature records were obtained. Three of these machines were borrowed from the California Forest Experiment Station. In rooms already equipped with machines the records were copied.

Moisture equipment

Moisture was determined on the dry weight basis. Known samples were collected weekly in tight jars, weighed as soon as possible and dried in a dryer oven for three hours. Because of the necessity of testing small samples uniform weights 4-5 gms were used in all cases and both weighings were made on finely adjusted laboratory balances. Mr. S. S. Jeffrey assisted materially in running the moisture determinations.

Cage equipment

A large cage was constructed in sections and brought into the laboratory for the purpose of caging infested bark and pine blocks. The cage (about 4 1/2 x 4 1/2 x 4 1/2 feet) (Fig. 2) was built by paper and constructed so that one side could be easily removed and blocks placed within or removed. It was placed on roofing paper and the bottom and sides lined with cotton batting to prevent the beetles from escaping. The reason for bringing this cage into the building was to take advantage of the room temperature and to accelerate beetle development, emergence and attack.

Logs and insects

A large quantity of infested bark containing mature larvae and two dozen short log sections (2 ft.) (Fig. 1) were collected in the field at Elanath Falls and shipped to Berkeley for the beginning of the work. When this supply had been exhausted more (also 2 ft.) material was collected during a short trip to the Stanislaus National Forest. Other shipments of infested bark were received from Jack Tanner, Reen, of the Sequoia National Park and from W. Hale ofeyerhouser Timber Company. The infested bark was used as needed. Some was kept at low temperatures for future use and some placed at high temperatures for early emergence. Entire blocks were stored in the open on the north side of a building until needed.

Miscellaneous

Retri dishes, jars and improvised boxes were used to contain brood of different stages for some of the experiments. (Fig. 3).

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Procedure

Bark infested with brood of the western pine beetle was collected in the field and caged in the laboratory for beetle emergence. Western yellow pine logs averaging two to three feet in length and ten to eighteen inches in diameter were shelled in from the field and caged with the emerging beetles. As soon as examinations showed that attack had been established on a pair of blocks they were immediately transferred to one of the constant temperature compartments and weekly moisture and brood records were made on one of the blocks, the other being kept for the final examination. Two complete sets of two blocks each were run in all available chambers.

Over five thousand mature larvae were obtained by shaving up infested bark and were used to determine the influence of temperature on rate of development of later brood stages. A daily schedule for transfer of these larvae was worked out so that different groups received different duration of exposure to various temperatures each day. Subsequent brood development was observed and recorded daily. Other groups of mature larvae were placed in the different constant temperature compartments and the rate of development noted weekly.

Eggs were dug from recently attacked blocks and isolated on moist blotting paper in petri dishes and these lots distributed in the compartments of lower temperature range in order to determine the lowest temperature at which they could hatch. (Fig. 8).

Western Pine Beetle Brood Development

The laboratory work on brood development of the western pine beetle was divided into two phases. First the development of brood within the infested blocks, and second the development of the more advanced brood obtained from infested bark. Part one of the study more nearly simulated conditions as found in felled logs and slash. It began with the attack and continued through the egg, larval, pupal and adult stages or as long as the brood remained alive. Part two had the advantage of permitting accurate isolation of a known number of larvae and of better observation of development through daily examination. This part of the study continued until the insects either reached the adult stage or were lost through mortality. This phase supplements the first one but in many respects gives us more definite information than could be obtained through examination of broods within the blocks.

Each temperature used will be discussed separately and not grouped as they were in graph II which indicates weekly phloem moisture of the infested blocks. In this case the two sets of experiments were averaged because the slight differences in phloem moisture of two series of blocks at similar temperatures did not warrant individual presentation.

Brood development in infested blocks

A presentation of western pine beetle brood development in infested blocks kept at constant temperatures will be found in table 1.

The following is a list of the names of the persons who have been appointed to the various committees of the Board of Directors of the American Red Cross, for the year 1917-1918. The names are given in alphabetical order of the surnames.

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Table 1.
Western Pine Beetle Brood Development in Infested Blocks
Kept at Constant Temperatures.

temperature degrees Fahrenheit	1st week		2nd week		3rd week		4th week		5th week		6th week		7th week	
	Moist. %	Brood	Moist. %	Brood	Moist. %	Brood	Moist. %	Brood	Moist. %	Brood	Moist. %	Brood	Moist. %	Brood
102-106	--	Active eggs hatched	187	All dead	167									
98-102	153	Eggs hatched	139	Larval mortality heavy	167	All dead	93							
93-97	--	Eggs hatched	278	Some lar- val mor- tality few 1/2	259	mortality heavy some 3/4	241	Larva 1/2 1 callow adult	232	No brood		Few small larvae		
93-97	139	Eggs hatched	180	Some lar- val mor- tality few 1/2	187	Larval mortality heavy	167	mortality heavy adults	191	Larval mortality heavy				
94-96	--	Eggs hatched	255	Some lar- val mor- tality	277	Heavy lar- val mor- tality.	308	No brood found	294	Larval mortality heavy.				
83-87	206	Eggs hatched	215	Light lar- val mor- tality	201	Some heavy mor- tality	177	Few larvae	209	Peel detached				
73-77	194	Eggs hatched	216	Small larvae	214	Larval mortality some 1/8	202	Larval mortality heavy 1/2	234	All dead				
65-75	222	Eggs hatched	225	Tiny larvae	290	Heavy mortality	238	Few liv- ing lar- vae	266	50% mortality larvae 1/2				
65-75	--	Eggs hatched	265	Small larvae	276	Good light larvae 1/2	252	Few small larvae one small pupae	269	1 new adult 1 small pupae few small larvae				
55-65	286	Eggs	279	Eggs hatched	296	Small larvae	--	Some mor- tality larvae 1/6	--	Some mor- tality larvae 1/2		Few larvae 1/2	182	Few small larvae
56-65	250	Eggs	226	Eggs hatched	243	Larvae abundant	242	Mortal- ity light larvae 1/8-1/4	255	Mostly living larvae 1/2		Few lar- vae in inner bark	224	Heavy larval mortality 2 small larvae
50-54	189	Eggs	214	Eggs	224	Eggs hatched	209	Larvae small	241	Larvae small		Larvae small 25-31.	224	Larvae small

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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80																				

Table 1. Cont'd.

Western Pine Beetle Brood Development in Infested Blocks
Kept at Constant Temperatures.

Temperature degrees Fahrenheit	1st week		2nd week		3rd week		4th week		5th week		6th week		7th week	
	Moist. %	Brood	Moist. %	Brood	Moist. %	Brood	Moist. %	Brood	Moist. %	Brood	Moist. %	Brood	Moist. %	Brood
45-50	--	Eggs	E49	Eggs	E76	Eggs	E78	Eggs	E60	Eggs	E97	Eggs		Eggs
56-58	--	Eggs	E52	Eggs	E49	Eggs	E46	Eggs	E30	Eggs	E12	Eggs		Eggs

中華民國二十六年
 五月二十日
 財政部

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	1221	12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Broods subjected to constant temperatures of 102 to 108 degrees F. were of short duration. Heavily infested blocks subjected to this temperature contained, at the end of five days, only dead parent adults (fig. 7) and unhatched eggs. The adults pushed out sandast for a short time after being in this chamber, but no activity or development could be found after the first week. Its slight reduction in pulvum moisture (25 per cent) in these blocks during the first week could not conceivably have any bearing on the brood mortality. It is therefore attributed to high lethal temperatures.

Brood in infested blocks subjected to constant temperatures of 95 to 102 degrees lasted but two weeks longer than at the higher temperature. Some of the eggs hatched during the first week, and the adults were active. However, heavy mortality occurred among the young larvae during the second week, although some larvae were recorded as one fourth mature. During the following ^{week} the mortality extended to include all larvae as well as the parent adults (fig. 7). A green fungus was associated with some of the dead larvae. Pulvum moisture decreased but slightly (10 per cent). The fact that both the adult and larval mortality occurred at about the same time indicates that here too mortality should be attributed to high temperature.

Two series of blocks were run at temperatures of 93 to 97 degrees, but because of differences in these tests they will be discussed separately. The first test at this temperature produced one callow adult in 28 days, the shortest time recorded for brood development of this insect. However, brood mortality in these blocks was heavy, and most of the brood found appeared as under-sized, under-nourished, rat-tailed larvae. The final examination at the end of six weeks showed a few small larvae burrowing around in the inner bark but no emergence. Pulvum moisture varied but little, remaining high throughout the experiment. Here with an example of complete development (egg to adult in 28 days at constant high temperature and constant high pulvum moisture content the reason for failure of most of the brood has been obscured.

In the second series of blocks at 93 to 97 degrees brood development appeared to progress rapidly during the first week. Then as with higher temperatures mortality was extremely high during the second and third week (fig. 8). Parent adults were found dead at the end of four weeks. A very few small larvae were still burrowing in the inner bark after the fifth week, but no other brood could be found. Here, too, the green fungus was associated with the dead larvae. It was found on them in both inner and outer bark. Pulvum moisture remained high but almost constant during the period covered by the examinations. If based alone on the results of the observations the cause of brood failures in the blocks cannot be determined. However, this temperature was found to be too high for proper development of brood in the advanced stages and is therefore probably the most important limiting factor in this case.

At constant temperatures from 84 to 88 degrees the parent adults were very active, the hatching of most of the eggs and abundance of active small larvae looked like the beginning of a good brood. By the end of the second week larval mortality began and was so heavy that after three weeks no brood was found until the final examination revealed a few small

larvae working in the cambium. A second test with the chamber operating between 83 and 87 degrees gave results so similar to the one just described that no discussion of it is necessary. Here, too, brood which appeared heavy and thrifty at first, gradually disappeared until at the end of four weeks almost no brood could be found, and that which did exist occurred only as small larvae. Phloem moisture decreased very little in the two series of blocks during the experiment. It remained high at all times, staying between 200 and 250 per cent.

Constant temperatures of 73 to 77 degrees resulted in a somewhat slower rate of brood development than higher temperatures, and the larvae lived on an average of about a week longer. Heavy brood occurred as larvae during the first three weeks. Slight mortality appeared the third week, and by the end of the fourth only an occasional living larva could be found. Phloem moisture remained between 200 and 224 per cent during this period. Here again it is evident that this temperature which has been shown to be very favorable for broods of the western pine beetle could have had no part in the resulting mortality.

Two tests at room temperatures which fluctuated between 68 and 75 degrees and averaged about 70 degrees gave slightly varying results. In the first test some brood reached maturity. At the end of the fourth week one small pupa was found, and two weeks later at the final examination, one new adult, one small pupa, and a few small larvae were present. Of outstanding significance is the minute size of the pupae and adults found in these blocks. They were much smaller than the smallest specimens obtained from the infested bark. Phloem moisture remained slightly above 200 per cent throughout the experiment. The second series of infested blocks run at the above temperature did not produce either pupae or adults, but one half grown larvae appeared in five weeks. As before, larval mortality was high during the fourth week. Phloem moisture varied only slightly less than in the preceding blocks.

In a room with temperature fluctuating between 55 and 65 degrees and averaging 60 degrees, almost all of the young larvae remained alive for four or five weeks. Only slight mortality occurred up to this time, but development was also much slower than in preceding cases. At this time larvae from one eighth to one fourth grown were abundant. During the following three weeks brood mortality increased so that at the final examination at the end of seven weeks only a few tiny larvae remained (fig. 4). Phloem moisture in these blocks increased from about 225 to nearly 300 per cent.

Small larvae and pupae.

One series of infested blocks subjected to very accurately controlled temperatures fluctuating occasionally and only for very short periods from 50 to 54 degrees, but for the most part remaining practically at 52 degrees showed very slow brood development. Eggs hatched at this temperature at the end of three weeks and small larvae remained as such with only slight development during the next four weeks. This is the lowest temperature at which apparent brood development occurred. Phloem moisture increased from about 210 to 240 during the study.

Small larvae and pupae.

Small larvae and pupae.

1. The first of these is the fact that the Commission has not yet received any information from the Government of the United States regarding the results of its investigation of the activities of the American Friends of the Soviet Union (AFSU) in the United States. The Commission is therefore unable to determine whether the AFSU is engaged in any activities which are prohibited by the laws of the United States.

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54 EAST LAKE STREET, CHICAGO, ILL. 60601
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1. The first of these is the fact that the majority of the population of the United States is now living in urban areas. This is a result of the process of urbanization, which has been going on since the beginning of the 20th century. The process of urbanization is the movement of people from rural areas to urban areas. This is a result of the fact that urban areas offer more opportunities for employment and education than rural areas do. The process of urbanization has led to the growth of large cities and the decline of small towns and villages. This has had a number of effects on the United States. One of the most important is that it has led to the concentration of the population in a few large cities. This has made it easier for the government to provide services to the population, but it has also led to the growth of slums and the problems of overcrowding and pollution. Another effect of urbanization is that it has led to the decline of the agricultural sector. This is because the majority of the population is now living in urban areas, and therefore there is less demand for agricultural products. This has led to the decline of the agricultural sector and the growth of the service sector. The service sector is the sector of the economy that provides services to the population. This includes the health care sector, the education sector, and the financial services sector. The service sector has grown rapidly in the United States, and it is now the largest sector of the economy. This is a result of the fact that the majority of the population is now living in urban areas, and therefore there is a high demand for services. The service sector has also led to the growth of the middle class. The middle class is the class of the population that is neither rich nor poor. It is the class that has the most power in the United States. The middle class has grown rapidly in the United States, and it is now the largest class of the population. This is a result of the fact that the majority of the population is now living in urban areas, and therefore there is a high demand for services. The middle class has also led to the growth of the consumer economy. The consumer economy is the economy that is based on the consumption of goods and services. This is the type of economy that we live in today. The consumer economy has led to the growth of the United States, and it is the reason why the United States is now one of the most powerful countries in the world. The consumer economy has also led to the growth of the service sector, and the service sector has led to the growth of the middle class. The middle class has led to the growth of the consumer economy, and the consumer economy has led to the growth of the service sector. This is a cycle that has led to the growth of the United States, and it is the reason why the United States is now one of the most powerful countries in the world.

THE STATE OF OHIO, ss: I, the undersigned, being a Justice of the Peace for and in and for the County of Hamilton, do hereby certify that the within and foregoing is a true and correct copy of the original of the same, as the same appears from the records of said County.

Blocks containing parent adults and eggs of the western pine beetle, placed in a low temperature chamber where temperatures varied from 45 to 55 degrees, showed no brood development in seven weeks. During the first three weeks the temperature remained below 50 degrees. Later it increased for short periods to as high as 55 degrees, but the average and most common temperature recorded in the chamber during these observations was about 48 degrees. Adult beetles were able to walk slowly at this temperature. In these blocks phloem moisture increased from about 25% to nearly 50% per cent. Here it is believed that low temperature prohibited development.

A still lower series of infested blocks was run at a constant temperature of 54 to 55 degrees, but after seven weeks the eggs still remained unhatched. At 55 degrees parent adults were barely capable of slow movement of legs, but they could not walk. When removed to room temperatures they recovered very quickly and appeared unharmed by long exposures at these low temperatures. Eggs from this material when transferred to room temperatures hatched within a few days. Here phloem moisture decreased from 25% to 21% per cent. The only other decreases obtained were in blocks at high temperatures. With the last series the absence of development is the result of low temperatures.

Development of advanced brood obtained from infested bark

In order to supplement brood development studies in infested blocks some fifteen hundred mature larvae were dug from infested bark brought in from the field during the winter months. These larvae were mixed in order to distribute any influence of previous development, and all except prepupal larvae were discarded. A given number were then selected for brood development tests, labelled in finely ground outer bark from which they had been taken and then distributed in jars in the various constant temperature compartments and subsequent rate of development carefully followed. These tests were duplicated for the purpose of insuring more accurate data than could be had from a single test. The results of these experiments are shown in graph III. Here temperatures have been grouped for graphic presentation but will be specifically discussed.

Constant temperatures from 101 to 106 degrees resulted in complete larval mortality within five days. Those from 94 to 101 gave similar results within ten days. These results agree with those obtained from the infested blocks at the same temperature.

At constant temperatures 83 to 87 degrees a few larvae transformed to pupae at the end of four days, although larval mortality was apparent within the jars. Within 12 days all larvae and all pupae succumbed to this temperature.

Jars of mature larvae in constant temperature chambers ranging from 83 to 87 degrees showed the first good brood development. At the end of two days pupae began forming and adults appeared after six days

It is the duty of the Government to provide for the health and safety of its citizens. This is a responsibility that cannot be delegated to any other authority. The Government must ensure that the laws and regulations are enforced to protect the public interest. It must also provide for the welfare of its citizens, especially in times of crisis. The Government should be transparent in its actions and accountable to the people. It should listen to the concerns of its citizens and respond to them in a timely manner. The Government should also promote the economic growth and development of the country. It should create jobs and improve the standard of living for its citizens. The Government should also protect the environment and ensure the sustainable use of natural resources. It should also promote the social justice and equality for all citizens. The Government should be a servant of the people and not a master. It should work for the common good and the well-being of the nation.

The Government should also ensure that the laws are fair and just. It should not discriminate against any group of people. It should protect the rights of its citizens and ensure that they are not violated. The Government should also promote the rule of law and ensure that everyone is held accountable to the law. It should not abuse its power and should use it for the benefit of the people. The Government should also promote the peace and stability of the country. It should resolve conflicts peacefully and should not engage in wars. The Government should also promote the cultural heritage and the traditions of the country. It should protect the historical sites and the cultural values of the nation. The Government should also promote the scientific research and the technological development. It should invest in education and research to improve the quality of life and the economy. The Government should also promote the international cooperation and the global peace. It should work with other countries to solve global problems and to promote the common interests of the world. The Government should be a leader and a role model for the people. It should inspire them and give them a sense of purpose and direction. The Government should be a source of pride and a symbol of the nation's greatness. It should work for the glory of the nation and the happiness of its citizens. The Government should be a servant of the people and not a master. It should work for the common good and the well-being of the nation.

THE DUTY OF THE GOVERNMENT TO PROVIDE FOR THE HEALTH AND SAFETY OF ITS CITIZENS

The Government has a duty to provide for the health and safety of its citizens. This duty is derived from the social contract theory, which states that the citizens have agreed to give up some of their freedoms in exchange for the protection and security provided by the Government. The Government must therefore ensure that it fulfills its duty to protect the health and safety of its citizens. This includes providing for the physical health of its citizens by ensuring that they have access to clean water, food, and shelter. It also includes providing for the mental health of its citizens by ensuring that they are not subjected to torture, oppression, or discrimination. The Government must also ensure that its laws and regulations are designed to protect the health and safety of its citizens. It must enforce these laws and regulations and take action against anyone who violates them. The Government must also provide for the health and safety of its citizens in times of crisis, such as natural disasters or wars. It must evacuate people from dangerous areas and provide them with food, shelter, and medical care. The Government must also ensure that its actions do not harm the health and safety of its citizens. It must not engage in wars or other actions that would cause unnecessary deaths and destruction. The Government must also ensure that its policies are based on the best available scientific evidence and that they are subject to regular review and evaluation. The Government must be transparent in its actions and accountable to the people. It must listen to the concerns of its citizens and respond to them in a timely manner. The Government must also promote the health and safety of its citizens through education and public health campaigns. It must encourage people to adopt healthy lifestyles and to take steps to protect themselves and others. The Government must be a servant of the people and not a master. It must work for the common good and the well-being of the nation.

The Government must also ensure that its actions are based on the principle of proportionality. This means that the Government must use the least restrictive means to achieve its goals and must not use force or coercion unless it is absolutely necessary. The Government must also ensure that its actions are based on the principle of non-discrimination. This means that the Government must not treat any group of people differently based on their race, ethnicity, religion, or other characteristics. The Government must also ensure that its actions are based on the principle of transparency. This means that the Government must make its decisions and actions open to public scrutiny and must provide information to the people in a timely and accessible manner. The Government must also ensure that its actions are based on the principle of accountability. This means that the Government must be held responsible for its actions and must be subject to legal and political consequences if it fails to fulfill its duty to its citizens. The Government must be a servant of the people and not a master. It must work for the common good and the well-being of the nation.

The Government must also ensure that its actions are based on the principle of sustainability. This means that the Government must not engage in actions that would harm the environment or deplete natural resources. The Government must also ensure that its actions are based on the principle of justice. This means that the Government must ensure that its policies and actions are fair and just and that they do not discriminate against any group of people. The Government must also ensure that its actions are based on the principle of peace. This means that the Government must not engage in wars or other actions that would cause unnecessary deaths and destruction. The Government must be a servant of the people and not a master. It must work for the common good and the well-being of the nation.

The Government must also ensure that its actions are based on the principle of democracy. This means that the Government must be elected by the people and must be subject to their control. The Government must also ensure that its actions are based on the principle of human rights. This means that the Government must respect the rights of its citizens and must not violate them. The Government must also ensure that its actions are based on the principle of international law. This means that the Government must follow the rules and norms of the international community and must not engage in actions that would violate these rules and norms. The Government must be a servant of the people and not a master. It must work for the common good and the well-being of the nation.

exposure. Within twelve days the jars contained only young adults and dead larvae and pupae. Mortality was high, being 52.2 per cent, but development of the brood which survived was rapid.

Constant temperatures 73 to 77 degrees resulted in slower development of the brood than at the preceding exposure. Pupae appeared as early as before (two days), but final adults appeared five days later than those at the higher temperature (17 days). At the lower temperature mortality was slightly less, being 44.1 per cent.

Development continued to slow up at lower temperatures. In a room varying from 65 to 75 and averaging 70 degrees, first pupae were observed at the end of two days, but the pupal period was prolonged to 23 days when the last adult appeared. A mortality of 30 per cent in this case was the lowest obtained in any of the tests with advanced broods.

A marked decrease in rate of brood development occurred within a constant temperature chamber running at 58 to 63 degrees with an average of 60 degrees. First pupae appeared in six days as against two in previous cases, and first adults in 26 days. It required 42 days for final adults to transform ^{to} pupae, and during this time mortality reached 54 per cent.

A jar of larvae placed at 50 to 54 degrees remained there for 14 days before one of them pupated. At the end of 42 days when the experiment was discontinued, approximately one third of the living insects had pupated. Mortality in this jar was 46 per cent.

Larvae in jars placed at constant low temperatures of 38 to 42 degrees and 34 to 38 degrees for 47 days were, to all outward appearances, about the same as when entered. No apparent development had occurred. A 49 per cent mortality resulted over this period.

Tests with recently laid eggs of the western pine beetle showed that temperatures necessary for incubation, hatching and early larval development corresponded very closely to those necessary for development of other stages. Two hundred fifty eggs were isolated on moist blotting paper in covered petri dishes (50 per dish) and distributed at constant temperatures of 36, 40, 52, 55, and 60 degrees respectively in order to determine the lowest temperature at which they would hatch. Within a period of 16 days 23 young larvae occurred at 60 degrees, 14 at 55 and 7 at 52 (fig. 5). Altho the remaining dishes at 40 and 36 were left for further study no eggs hatched within them during a period of three weeks. This corresponds closely with records on eggs within the infested blocks and also with development of other brood stages.

Two hundred mature larvae were divided into lots of 50 each and placed on blotting paper in petri dishes to check the effect of humidity on survival and development. Dry blotting paper was used in two dishes and wet in the other two. A wet and a dry group were placed at a constant temperature of 95 degrees and a similar set put into the chamber kept at 100 degrees. It was thought that the moisture might prolong the survival of the insects in the wetter dishes. These two series were examined

daily for five days, but no difference in mortality could be noted. At the end of this period mortality was almost complete in all dishes. Mold in the dishes with wet blotting paper developed extensively on the larvae while those under drier conditions appeared to have suffered mortality through heat and desiccation. The wet larvae turned very black and swelled. The dry larvae shriveled and turned to a yellowish color.

Discussion

Either with young brood in infested blocks or more advanced brood from infested bark, it is apparent that temperature plays a very important part in determining the rate of brood development. With both sets there was no apparent brood development at temperatures below 50 degrees. Above 50 degrees the rate of brood development increased with the temperatures until the point was reached where lethal temperatures caused death. The most rapid brood development occurred just before lethal temperatures were reached.

Moisture was practically constant in the test blocks and was always high, averaging from 200 to 300 per cent. Similar conditions are found in slash in the field and apparently is not conducive to good brood development.

The mortality which occurred in the laboratory tests cannot be fully explained. With mature larvae in dry powdered bark 30 per cent or more mortality occurred. This might have been due to handling, to change in environmental conditions or to desiccation. Since most mortality occurred during stages of transformation from larvae to pupae and pupae to adults it is believed that desiccation prevented these delicate changes. Larvae with split head capsules and skins which failed to slough off were common. Also pupae whose wings appeared to stick fast in place, thus preventing complete transformation to adults, were common. Mortality in advanced broods under favorable temperatures except at these critical points was seldom found. For temperatures of 95 degrees or over complete mortality was evidently due to lethal temperatures. This idea was further supported when similar rates of mortality occurred at these temperatures in groups of mature larvae kept under either wet or dry conditions.

With the immature larvae in the logs the higher mortality must be due to either one or all of the following causes:

Excessive phloem moisture of 200 to 300 per cent which invariably obtains in logs and slash kept within the temperature limits for brood development may be responsible either directly or indirectly for a large share of the brood mortality. We know that in standing trees where brood development of the western pine beetle proceeds normally there is rapid loss of moisture which accompanies good brood development. On the other hand, logs and slash where broods of this insect fail to develop properly there is an increase in phloem moisture. Similarly brood in infested blocks was subjected to the higher moisture conditions, while that in the jars where more successful development occurred were exposed only

to the dry media of pulverized outer bark. Whether the effect of excessive moisture was direct or indirect is unknown, however, phloem moisture content and brood failures appear to be so closely related that one may be used as an indicator of the other.

The theory that nutritional disturbance may be largely responsible for brood failure of this insect is rapidly winning support. Preliminary experiments by Jeffrey* working on felled logs both in the field and under laboratory conditions indicate that very important food changes occur in the inner bark soon after cutting. He finds that certain sugars appear to increase slightly at first and then to decrease within a few days to practically nothing. In the experiments on brood development there is much evidence supporting the theory of the importance of malnutrition in brood failures. Comparing the two sets of experiments previously discussed the larvae in the logs were in the active feeding stage and were dependent on the inner bark for their nourishment. The mature larvae in jars had completed their feeding in standing trees and were no longer dependent upon food for their existence or further development. Changes in nutritional value of the food would therefore be reflected in the success or failure of brood in the blocks but not in that of the advanced larvae. The half-starved, under-nourished, rat-tailed appearance of the larvae in blocks; the fact that they make abnormally long winding larval galleries, as if in search for food; the unusually long period spent in the inner bark, and the slow death of many of them all support the theory of insufficient nourishment.

*Jeffrey, R. W., The concentration of certain sugars in the bark of the western yellow pine as relates to western pine beetle attraction. Sta. Rep. 1930 Ber. Cal.

The activity of fungi associated with the dead broods invariably commanded attention. A green fungus identified by Wagoner* as a Penicillium was particularly abundant in the larval galleries where the brood had failed. Whether this fungus plays a part in the death of the larvae or whether it merely finds good growing conditions on the bodies of dead larvae is not known. However, because of the generally saprophytic nature of this group of fungi it is believed to be of little importance in the death of the insects.

Effect of cumulative temperatures

A second phase of brood development studies using brood in the more advanced stages was conducted, using some three thousand mature larvae. These experiments were designed to determine the number of daily effective hours necessary for beginning of development of hibernating broods. Other points to be determined were rate of development as influenced by cumulative temperatures and whether or not alternating temperatures stimulated brood development.

*Wagoner, W. W., Office of Bureau of Plant Industry, San Francisco, Calif.

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The second volume of this series is equally important. It contains
 a collection of papers by various authors on the subject of the
 development of the human mind. The papers are arranged in a
 logical order, and the volume is a valuable addition to the
 literature of the subject. It is a book that should be read by
 all who are interested in the development of the human mind.

1. The first step is to identify the problem or question that needs to be answered. This involves understanding the context and the specific requirements of the task.

It is believed that the above information is the best available at this time.

1991-1992, 1993-1994, 1995-1996, 1997-1998, 1999-2000, 2001-2002, 2003-2004, 2005-2006, 2007-2008, 2009-2010, 2011-2012, 2013-2014, 2015-2016, 2017-2018, 2019-2020, 2021-2022, 2023-2024, 2025-2026, 2027-2028, 2029-2030, 2031-2032, 2033-2034, 2035-2036, 2037-2038, 2039-2040, 2041-2042, 2043-2044, 2045-2046, 2047-2048, 2049-2050, 2051-2052, 2053-2054, 2055-2056, 2057-2058, 2059-2060, 2061-2062, 2063-2064, 2065-2066, 2067-2068, 2069-2070, 2071-2072, 2073-2074, 2075-2076, 2077-2078, 2079-2080, 2081-2082, 2083-2084, 2085-2086, 2087-2088, 2089-2090, 2091-2092, 2093-2094, 2095-2096, 2097-2098, 2099-2100, 2101-2102, 2103-2104, 2105-2106, 2107-2108, 2109-2110, 2111-2112, 2113-2114, 2115-2116, 2117-2118, 2119-2120, 2121-2122, 2123-2124, 2125-2126, 2127-2128, 2129-2130, 2131-2132, 2133-2134, 2135-2136, 2137-2138, 2139-2140, 2141-2142, 2143-2144, 2145-2146, 2147-2148, 2149-2150, 2151-2152, 2153-2154, 2155-2156, 2157-2158, 2159-2160, 2161-2162, 2163-2164, 2165-2166, 2167-2168, 2169-2170, 2171-2172, 2173-2174, 2175-2176, 2177-2178, 2179-2180, 2181-2182, 2183-2184, 2185-2186, 2187-2188, 2189-2190, 2191-2192, 2193-2194, 2195-2196, 2197-2198, 2199-2200, 2201-2202, 2203-2204, 2205-2206, 2207-2208, 2209-2210, 2211-2212, 2213-2214, 2215-2216, 2217-2218, 2219-2220, 2221-2222, 2223-2224, 2225-2226, 2227-2228, 2229-2230, 2231-2232, 2233-2234, 2235-2236, 2237-2238, 2239-2240, 2241-2242, 2243-2244, 2245-2246, 2247-2248, 2249-2250, 2251-2252, 2253-2254, 2255-2256, 2257-2258, 2259-2260, 2261-2262, 2263-2264, 2265-2266, 2267-2268, 2269-2270, 2271-2272, 2273-2274, 2275-2276, 2277-2278, 2279-2280, 2281-2282, 2283-2284, 2285-2286, 2287-2288, 2289-2290, 2291-2292, 2293-2294, 2295-2296, 2297-2298, 2299-2300, 2301-2302, 2303-2304, 2305-2306, 2307-2308, 2309-2310, 2311-2312, 2313-2314, 2315-2316, 2317-2318, 2319-2320, 2321-2322, 2323-2324, 2325-2326, 2327-2328, 2329-2330, 2331-2332, 2333-2334, 2335-2336, 2337-2338, 2339-2340, 2341-2342, 2343-2344, 2345-2346, 2347-2348, 2349-2350, 2351-2352, 2353-2354, 2355-2356, 2357-2358, 2359-2360, 2361-2362, 2363-2364, 2365-2366, 2367-2368, 2369-2370, 2371-2372, 2373-2374, 2375-2376, 2377-2378, 2379-2380, 2381-2382, 2383-2384, 2385-2386, 2387-2388, 2389-2390, 2391-2392, 2393-2394, 2395-2396, 2397-2398, 2399-2400, 2401-2402, 2403-2404, 2405-2406, 2407-2408, 2409-2410, 2411-2412, 2413-2414, 2415-2416, 2417-2418, 2419-2420, 2421-2422, 2423-2424, 2425-2426, 2427-2428, 2429-2430, 2431-2432, 2433-2434, 2435-2436, 2437-2438, 2439-2440, 2441-2442, 2443-2444, 2445-2446, 2447-2448, 2449-2450, 2451-2452, 2453-2454, 2455-2456, 2457-2458, 2459-2460, 2461-2462, 2463-2464, 2465-2466, 2467-2468, 2469-2470, 2471-2472, 2473-2474, 2475-2476, 2477-2478, 2479-2480, 2481-2482, 2483-2484, 2485-2486, 2487-2488, 2489-2490, 2491-2492, 2493-2494, 2495-2496, 2497-2498, 2499-2500, 2501-2502, 2503-2504, 2505-2506, 2507-2508, 2509-2510, 2511-2512, 2513-2514, 2515-2516, 2517-2518, 2519-2520, 2521-2522, 2523-2524, 2525-2526, 2527-2528, 2529-2530, 2531-2532, 2533-2534, 2535-2536, 2537-2538, 2539-2540, 2541-2542, 2543-2544, 2545-2546, 2547-2548, 2549-2550, 2551-2552, 2553-2554, 2555-2556, 2557-2558, 2559-2560, 2561-2562, 2563-2564, 2565-2566, 2567-2568, 2569-2570, 2571-2572, 2573-2574, 2575-2576, 2577-2578, 2579-2580, 2581-2582, 2583-2584, 2585-2586, 2587-2588, 2589-2590, 2591-2592, 2593-2594, 2595-2596, 2597-2598, 2599-2600, 2601-2602, 2603-2604, 2605-2606, 2607-2608, 2609-2610, 2611-2612, 2613-2614, 2615-2616, 2617-2618, 2619-2620, 2621-2622, 2623-2624, 2625-2626, 2627-2628, 2629-2630, 2631-2632, 2633-2634, 2635-2636, 2637-2638, 2639-2640, 2641-2642, 2643-2644, 2645-2646, 2647-2648, 2649-2650, 2651-2652, 2653-2654, 2655-2656, 2657-2658, 2659-2660, 2661-2662, 2663-2664, 2665-2666, 2667-2668, 2669-2670, 2671-2672, 2673-2674, 2675-2676, 2677-2678, 2679-2680, 2681-2682, 2683-2684, 2685-2686, 2687-2688, 2689-2690, 2691-2692, 2693-2694, 2695-2696, 2697-2698, 2699-2700, 2701-2702, 2703-2704, 2705-2706, 2707-2708, 2709-2710, 2711-2712, 2713-2714, 2715-2716, 2717-2718, 2719-2720, 2721-2722, 2723-2724, 2725-2726, 2727-2728, 2729-2730, 2731-2732, 2733-2734, 27

1. The first of these is the fact that the Commission has not yet received any information from the Government of the United States regarding the activities of the Committee for the Liberation of the Americas (CLA) in the United States. The Commission is therefore unable to determine whether the CLA is active in the United States or whether it is merely a front organization for the CIA.

1940-1941

Hibernating larvae from infested bark were obtained and sorted as previously described and placed in numbered containers (fig. 4) which were altered from constant temperature 40 to 75 degrees for a given number of hours daily. Since 40 had been found to be below the threshold of development, a compartment at this temperature was used in which to keep all broods when not at 75 degrees, which was the temperature selected for good development. Brood development was assumed to have occurred only during the hours spent at the higher temperature. The tests were run three times, using on each occasion eleven jars containing 50 mature larvae. One test of eleven jars containing half grown larvae was tried, but because of excessive brood mortality was discontinued. In this lot of larvae feeding had apparently not been completed. A fourth series was run using infested bark containing half grown larvae, many of which later emerged as adults. The daily schedule which was worked out for the transfer of jars should help to explain how this material was handled.

Table II. DAILY SCHEDULE FOR TRANSFER OF BROOD JARS,
CONTAINING BROOD OF THE WESTERN PINE BEETLE.

Container number											
Time	1	2	3	4	5	6	7	8	9	10	11
of	12	13	14	15	16	17	18	19	20	21	22
change	23	24	25	26	27	28	29	30	31	32	33
	34	35	36	37	38	39	40	41	42	43	44
	45	46	47	48	49	50	51	52	53	54	55
Temperature											
9 a.m.	40	40	40	40	40	40	75	75	75	75	75
11 a.m.	75										40
1 p.m.		75								40	
3 p.m.			75						40		
5 p.m.				75				40			
7 p.m.					75		40				
9 p.m.						75					

† At 9 a.m. all specimens are returned to original temperatures

Explanation of chart:

Jars 1, 12, 23, 34, and 45 are placed at 40 degrees at 9 a.m. each morning and at 75 degrees at 11 a.m. Likewise the other columns of jar numbers follow the changes indicated below them at the periods indicated.

It will be noticed from table II that jars of mature larvae were so transferred as to give a complete series of exposures of two hours variation from two to twenty two hours daily at a high temperature favorable for development. Likewise this series reversed resulted in exposures at low temperatures below development of from two to twenty two hours daily. Many of these transfers to different compartments continued over a period of fifty days. Any apparent brood development was noted and recorded daily.

It was recognized that when jars of insects were transferred from a temperature of ~~40~~ to one of 75 degrees and visa versa there would be considerable lapse of time before they reached the surrounding air temperature. In order to measure this lag, thermometers were placed in four of the jars and readings taken every fifteen minutes until adjustment of temperatures had occurred. It was found that changes in both directions required but one hour for completion and therefore lag did not affect the experiments. Any loss in development due to lag following a transfer from ~~40~~ to 75 degrees would be made up in the one from 75 to ~~40~~ the degree compartment.

Since a temperature of approximately 50 degrees F. was determined to be the point at which development of the western pine beetle began, it has been possible to compute hour-degrees of effective temperatures. For example one degree of temperature above the zero of development, enduring for a period of an hour, constitutes an hour-degree.

Results of three series of alternating temperature experiments using 1650 mature larvae are tabulated and presented in table III. Also the rate of brood development of this insect is compared with the hour-degrees of cumulative temperatures in graph I.

TABLE III. Brood development of (*Dendroctonus brevicornis* Lec-
as affected by temperature
(prepupal larvae to adults)

Exposure per day at 25° F.	No. insects	Percent Mortality	First pu- pae		Average pu- pae		Pupae to adult average		First adults		Mature larvae to most pupae		Mature lar- vae to adult average		Larvae to final adults	
			Days	Hour	Days	Hour	Days	Hour	Days	Hour	Days	Hour	Days	Hour	Days	Hour
			Exp. deg.	Exp. deg.	Exp. deg.	Exp. deg.	Exp. deg.	Exp. deg.	Exp. deg.	Exp. deg.	Exp. deg.	Exp. deg.	Exp. deg.	Exp. deg.	Exp. deg.	Exp. deg.
22 Hrs.	150	32%	1.6	916	5.9	5248	7.5	4125	9.7	4812	8.6	4766	13.4	7370	19.0	10,450
20 hrs.	150	26%	2.0	1000	6.3	2450	9.0	4000	9.7	4850	11.0	5500	14.9	7450	20.7	10,575
18 hrs.	150	30%	1.8	964	7.3	2285	8.5	3875	10.3	4612	11.8	5323	15.3	7110	22.0	9,900
16 hrs.	150	33%	2.2	900	7.8	5120	10.5	4100	11.4	4800	12.0	4800	15.3	7220	21.5	9,675
14 hrs.	150	33%	3.3	1164	9.0	3150	10.9	3825	13.7	4812	14.3	5016	19.3	6975	26.7	9,362
12 hrs.	150	32%	4.0	1200	10.3	3090	13.9	4170	16.0	4800	18.0	5400	24.2	7260	34.0	10,200
10 hrs.	150	32%	3.3	964	12.3	2550	16.0	4000	13.4	4562	19.6	4916	28.0	7050	42.0	10,500
8 hrs.	150	--	4.0	800	13.3	3660	23.5	4700	24.7	4950	26.5	5300	41.3	8360	--	--
6 hrs.	150	--	6.3	920	22.0	2300	29.0	4350	22.0	4900	--	--	51.0	7650	--	--
4 hrs.	150	--	10.	1000	--	--	--	--	--	--	--	--	--	--	--	--
2 hrs.	150	--	21.	1050	--	--	--	--	--	--	--	--	--	--	--	--
average	Total 1650	51%		910		3260		4121		4744		6127		7382		10,066

From the above table the days and hours exposure of different lots of larvae and subsequent development to more advanced stages can be very easily seen. Brood mortality in all of the containers was remarkably uniform, averaging slightly over 30 per cent. It will be noted that first pupae appeared from 2 to 21 days according to the hours exposure per day, and that some variation is also shown in the hour-degrees of development. This difference may be due to previously encountered temperatures of which we have no record. Other temperature summations are so uniform that they indicate an error in this first column.

Average pupae indicated by the time when the greatest number of larvae transformed to pupae averaged from about 6 to 22 days according to hours exposure per day, but when effective hour-degrees are summated they are strikingly close together (about 3200).

Average pupae to average adult, the time elapsing between transformation of largest number of larvae to pupae and transformation of largest number of pupae to adults also varies in days from 7 to 29 but as shown from computed hour-degrees development depends uniformly on exposure to temperature (4000 hour-degrees). The appearance of first adults also follows this same trend (4700 hour-degrees). Furthermore the summations of overlapping brood stages such as mature larvae to most pupae, mature larvae to average adults and larvae to final adults all result in approximately the same number of hour-degrees for a specific developmental stage. Because of the normal lag found in growth of some individuals final summations are often inclined to be somewhat out of line, but the average should present a more accurate picture of conditions.

A summation of the hour-degrees of effective temperature necessary for development from mature larvae to final adults at different constant temperatures as determined with 1125 specimens proved to be about 10,000 in all cases which had the time for completion. This agrees closely with similar summations obtained at alternating temperatures. Table III is the summation of alternating temperatures and table IV the summation of different constant temperatures. The hour-degrees obtained in both experiments for development of mature larvae to final adults is about 10,000.

Table IV
Effect of different constant temperatures on brood development of the western pine beetle

Temperature degrees F.	Number insects	Mortality per cent	Larvae to final adults Days exp.	Hour-degrees	Remarks
98° - 106°	125	100	10 days		
95° - 97°	125	100	19 "		
83° - 87°	125	52.2	12 "	10,080	
73° - 77°	125	44.1	17 "	10,200	
65° - 75°	125	30.0	21 "	10,080	
58° - 63°	125	54.0	42 "	10,080	
50° - 54°	125	46.0	41 "	—	15 pupae
38° - 42°	125	40.0	47 "	—	No development
34° - 38°	125	36.0	47 "	—	No development

That the above facts are true and were obtained in different
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TABLE 12

NUMBER OF DIFFERENT COUNTRIES REPRESENTED IN EACH DEPARTMENT

BY THE NUMBER OF DELEGATES

DEPARTMENT	NUMBER OF DELEGATES	NUMBER OF COUNTRIES REPRESENTED
1st	10	10
2nd	10	10
3rd	10	10
4th	10	10
5th	10	10
6th	10	10
7th	10	10
8th	10	10
9th	10	10
10th	10	10
11th	10	10
12th	10	10
13th	10	10
14th	10	10
15th	10	10
16th	10	10
17th	10	10
18th	10	10
19th	10	10
20th	10	10

At a constant temperature of 85 degrees the time required for all larvae to pass through the pupal stage and transform to adults was but twelve days. The number of days necessary for this degree of development increased until it required forty two days at 60 degrees. The time required for development of larvae to adults in hour-degrees was always about 10,000. This held true regardless of the manner of application of effective temperatures.

Alternating temperatures appeared to have no stimulating effect upon brood development. It depended directly upon the application of effective temperatures.

Comments

Intensive studies on the effect of temperature upon the rate of brood development of the western pine beetle have given us some pretty definite information upon this point. We have determined the point at which development begins as the temperature rises and at which it ceases as the temperature falls. We know that the rate of brood development depends directly upon the hour-degrees of effective temperature. We were also able to determine that alternating high and low temperatures do not tend to accelerate brood development. Furthermore, the range of optimum development as determined by the most insects produced has been pretty well established. Finally, the high lethal temperature preventing development of this insect has been determined.

Similar intensive studies on temperature and its effect upon some of our other more important forest insects would add much to our knowledge of their activities.

It is felt that the value of some of the findings on effect of temperature on brood development may have been minimized by the unsatisfactory phloem moisture conditions prevailing in the infested logs and blocks used. Successful control of phloem moisture in infested blocks under laboratory conditions would greatly add to the value of the work already done on brood development. Some satisfactory method of increasing evaporation from the blocks thru thorough ventilation could probably be evolved from a few empirical tests. More positive experiments on the effect of controlled phloem moisture and atmospheric humidity, especially the former, should precede or at least accompany nutritional studies on this insect. The two phases are apparently closely inter-related and might well be investigated together.

Conclusions

From the foregoing brood study on development of the western pine beetle a few tentative conclusions may be drawn.

Brood development of this insect begins at about fifty degrees Fahrenheit.

The rate of brood development increases directly with the temperature up to about eighty five degrees Fahrenheit.

As a technical instrument of the Government of the United States, the Department of the Interior is authorized to acquire and hold land for the purpose of carrying out the public lands laws. The Department is authorized to acquire and hold land for the purpose of carrying out the public lands laws. The Department is authorized to acquire and hold land for the purpose of carrying out the public lands laws.

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Section 1

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Section 2

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Constant temperatures of ninety five and above, if sufficiently maintained, are fatal to all stages.

Most rapid development occurs at about eighty five degrees, but most successful development from the standpoint of greatest numbers of insects produced is in the vicinity of seventy to seventy five degrees.

Phloem moisture of infested felled material increases or remains abnormally high in all cases except at high lethal temperatures where some drying occurs.

The western pine beetle develops very poor broods under the range of temperature and moisture conditions obtained in blocks in the laboratory and slash in the field.

Failure of broods to develop at low temperatures below fifty degrees Fahrenheit and at high temperatures above ninety five degrees are probably due to the effect of limiting temperatures.

Brood failures occurring within favorable temperature zones are probably due to excessive moisture of the inner bark or some factor closely associated with it. Malnutrition and an abundant green Penicillium are probably two very important factors.

Daily changes in temperature appear to have no stimulating effect on the rate of brood development.

A definite number of hour-degrees of effective temperatures are necessary for the development of a specific brood stage of the western pine beetle.

A thermograph record of early spring and summer temperatures would probably be very useful in determining the time of emergence of overwintering broods in any particular area.

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Fig. 1



Fig. 2



Fig. (1) Pine blocks used in brood study of western pine beetle.
Fig. (2) Pine blocks and infested bark in cage used for obtaining attack.

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5. 6. 7. 8.

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Fig. 3



Fig. 4.

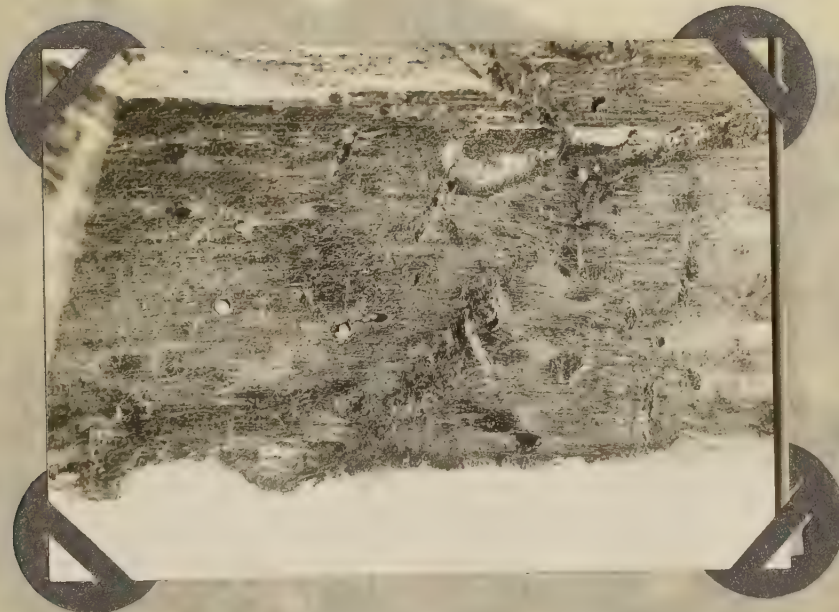


Fig. (3)-Infested bark, jars and petri dishes containing insects used in brood development study.

Fig. (4)-Inner bark from infested block showing tiny larvae seven weeks old (Note. most brood here dead).

[illegible]

1. The first step is to identify the problem or question that needs to be answered. This involves understanding the context and the specific information required.

Fig. 5.



Fig. 6.



Fig. (5) D.b. eggs and newly hatched larvae much enlarged on blotting paper in controlled temperature chamber.

Fig. (6) D.b. tiny larvae, x2 dead larvae and abnormally long larval galleries of infested block at 95° F.



THESE STAMPS WERE USED BY THE
POST OFFICE AT NEW YORK
IN THE YEAR 1845
AND ARE NOW IN THE
POSSESSION OF THE
LIBRARY OF THE
CONGRESS

FIG. 7.

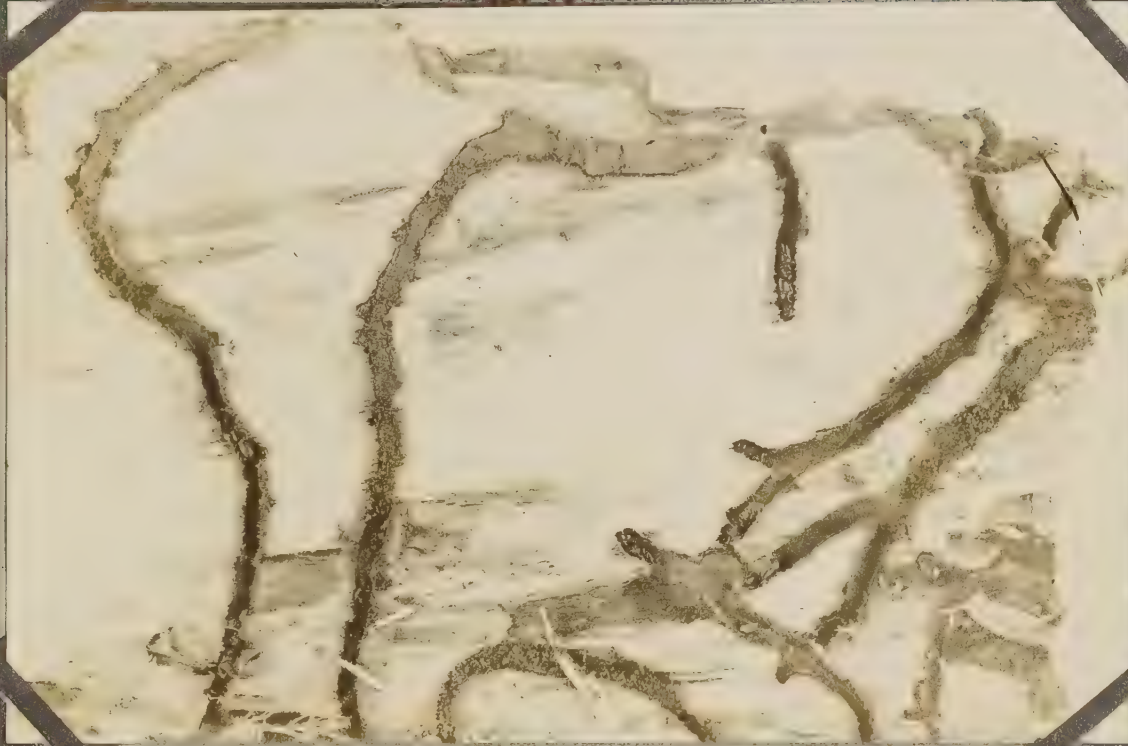


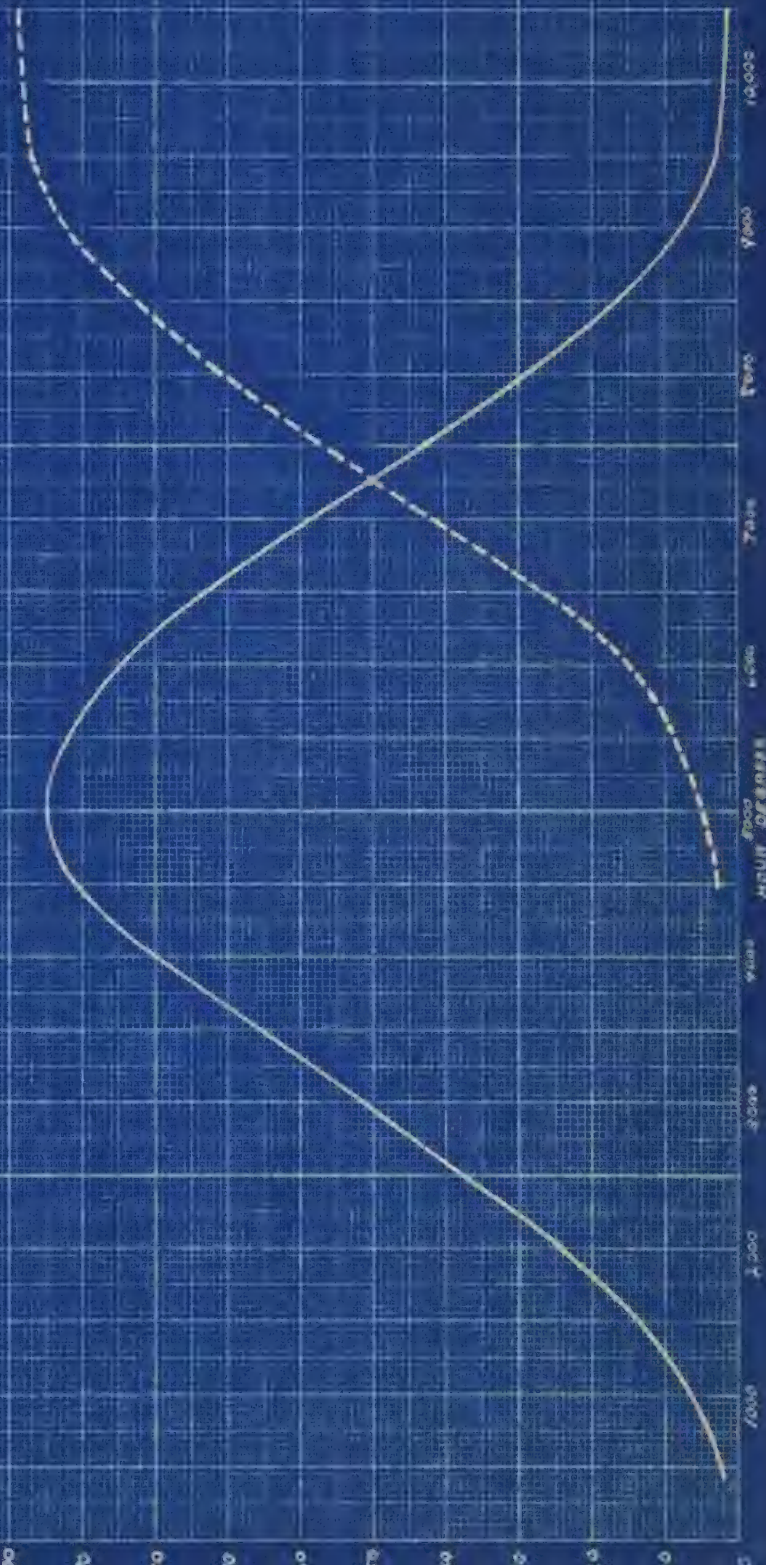
Fig. (7) Showing D.b. galleries and egg niches and dead adults in infested block from constant temperature chamber of 100° F.

1871

At present the only thing that is left of the old building is the chimney. The rest has been removed. The building was built in 1871. It was the first building of the kind in the city. It was built by the city of New York. It was the first building of the kind in the city. It was built by the city of New York.

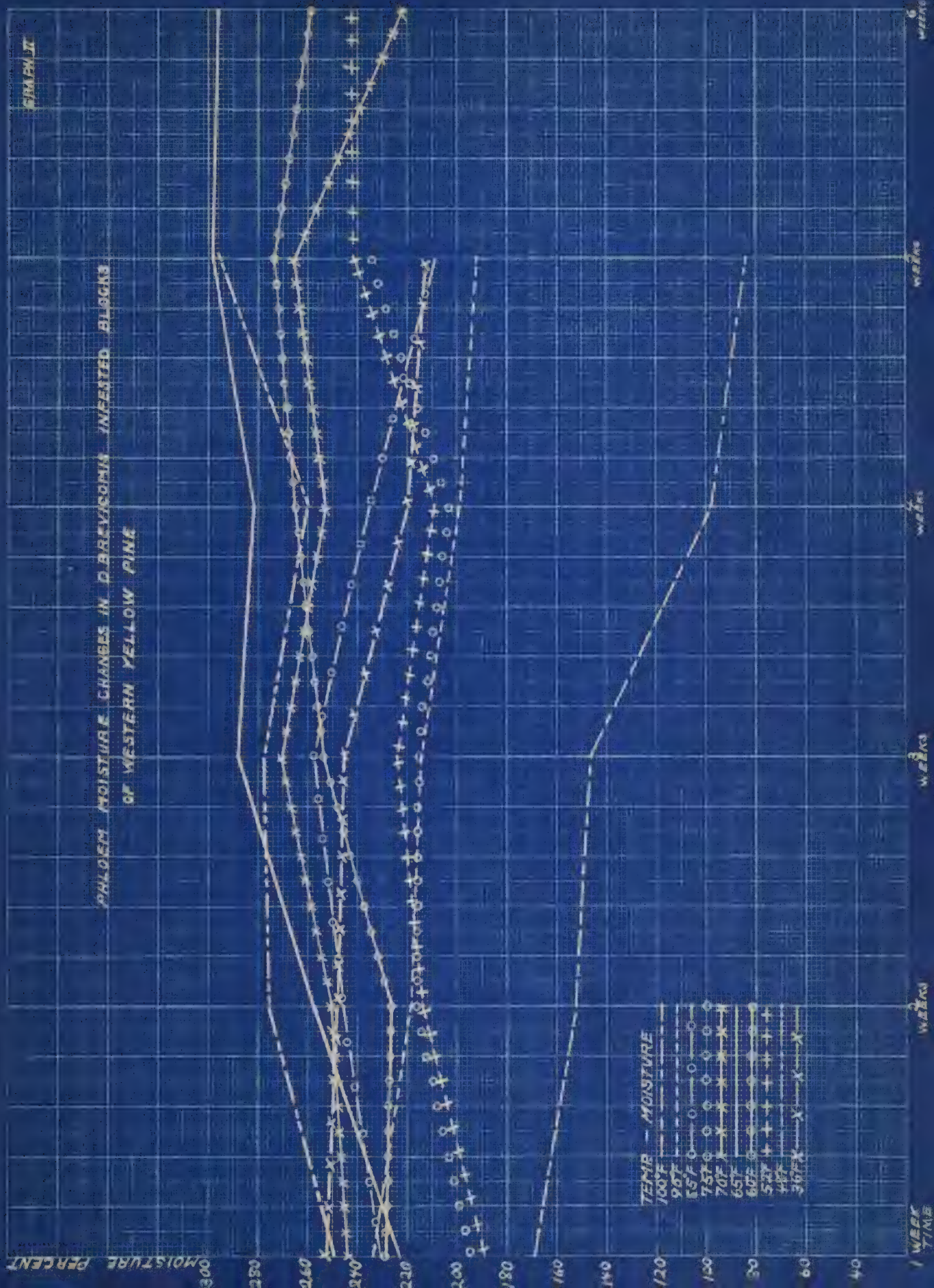
BROAD DEVELOPMENT OF *P. SATURNIUS* - PERCENTAGE LARVAE TO ADULTS -
AS AFFECTED BY ACCUMULATIVE TEMPERATURES

PUPAE
ADULTS



24

WOMEN EFFECTIVELY PARTICIPATE IN DECISION MAKING AND WOMEN ARE EQUAL TO MEN



BROOD DEVELOPMENT OF DENDROCTONUS BREVICORNIS AS INFLUENCED BY TEMPERATURE
(MATURE LARVAE TO ADULTS)

